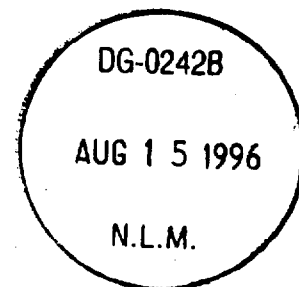


Physical Activity and Health

A Report of the Surgeon General



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Center for Chronic Disease Prevention and Health Promotion
The President's Council on Physical Fitness and Sports

Suggested Citation

U.S. Department of Health and Human Services. *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996.

For sale by the Superintendent of Documents,
P.O. Box 371954, Pittsburgh, PA 15250-7954,
S/N 017-023-00196-5

Message from Donna E. Shalala

Secretary of Health and Human Services

The United States has led the world in understanding and promoting the benefits of physical activity. In the 1950s, we launched the first national effort to encourage young Americans to be physically active, with a strong emphasis on participation in team sports. In the 1970s, we embarked on a national effort to educate Americans about the cardiovascular benefits of vigorous activity, such as running and playing basketball. And in the 1980s and 1990s, we made breakthrough findings about the health benefits of moderate-intensity activities, such as walking, gardening, and dancing.

Now, with the publication of this first Surgeon General's report on physical activity and health, which I commissioned in 1994, we are poised to take another bold step forward. This landmark review of the research on physical activity and health—the most comprehensive ever—has the potential to catalyze a new physical activity and fitness movement in the United States. It is a work of real significance, on par with the Surgeon General's historic first report on smoking and health published in 1964.

This report is a passport to good health for all Americans. Its key finding is that people of all ages can improve the quality of their lives through a lifelong practice of moderate physical activity. You don't have to be training for the Boston Marathon to derive real health benefits from physical activity. A regular, preferably daily regimen of at least 30–45 minutes of brisk walking, bicycling, or even working around the house or yard will reduce your risks of developing coronary heart disease, hypertension, colon cancer, and diabetes. And if you're already doing that, you should consider picking up the pace: this report says that people who are already physically active will benefit even more by increasing the intensity or duration of their activity.

This watershed report comes not a moment too soon. We have found that 60 percent—well over half—of Americans are not regularly active. Worse yet, 25 percent of Americans are not active at all. For young people—the future of our country—physical activity declines dramatically during adolescence. These are dangerous trends. We need to turn them around quickly, for the health of our citizens and our country.

We will do so only with a massive national commitment—beginning now, on the eve of the Centennial Olympic Games, with a true fitness Dream Team drawing on the many forms of leadership that make up our great democratic society. Families need to weave physical activity into the fabric of their daily lives. Health professionals, in addition to being role models for healthy behaviors, need to encourage their patients to get out of their chairs and start fitness programs tailored to their individual needs. Businesses need to learn from what has worked in the past

and promote worksite fitness, an easy option for workers. Community leaders need to reexamine whether enough resources have been devoted to the maintenance of parks, playgrounds, community centers, and physical education. Schools and universities need to reintroduce daily, quality physical activity as a key component of a comprehensive education. And the media and entertainment industries need to use their vast creative abilities to show all Americans that physical activity is healthful and fun—in other words, that it is attractive, maybe even glamorous!

We Americans always find the will to change when change is needed. I believe we can team up to create a new physical activity movement in this country. In doing so, we will save precious resources, precious futures, and precious lives. The time for action—and activity—is now.

Foreword

This first Surgeon General's report on physical activity is being released on the eve of the Centennial Olympic Games—the premiere event showcasing the world's greatest athletes. It is fitting that the games are being held in Atlanta, Georgia, home of the Centers for Disease Control and Prevention (CDC), the lead federal agency in preparing this report. The games' 100-year celebration also coincides with the CDC's landmark 50th year and with the 40th anniversary of the President's Council on Physical Fitness and Sports (PCPFS), the CDC's partner in developing this report. Because physical activity is a widely achievable means to a healthier life, this report directly supports the CDC's mission—to promote health and quality of life by preventing and controlling disease, injury, and disability. Also clear is the link to the PCPFS; originally established as part of a national campaign to help shape up America's younger generation, the Council continues today to promote physical activity, fitness, and sports for Americans of all ages.

The Olympic Games represent the summit of athletic achievement. The Paralympics, an international competition that will occur later this summer in Atlanta, represents the peak of athletic accomplishment for athletes with disabilities. Few of us will approach these levels of performance in our own physical endeavors. The good news in this report is that we do not have to scale Olympian heights to achieve significant health benefits. We can improve the quality of our lives through a lifelong practice of moderate amounts of regular physical activity of moderate or vigorous intensity. An active lifestyle is available to all.

Many Americans may be surprised at the extent and strength of the evidence linking physical activity to numerous health improvements. Most significantly, regular physical activity greatly reduces the risk of dying from coronary heart disease, the leading cause of death in the United States. Physical activity also reduces the risk of developing diabetes, hypertension, and colon cancer; enhances mental health; fosters healthy muscles, bones and joints; and helps maintain function and preserve independence in older adults.

The evidence about what helps people incorporate physical activity into their lives is less clear-cut. We do know that effective strategies and policies have taken place in settings as diverse as physical education classes in schools, health promotion programs at worksites, and one-on-one counseling by health care providers. However, more needs to be learned about what helps individuals change their physical activity habits and how changes in community environments, policies, and social norms might support that process.

Support is greatly needed if physical activity is to be increased in a society as technologically advanced as ours. Most Americans today are spared the burden of excessive physical labor. Indeed, few occupations today require significant physical

activity, and most people use motorized transportation to get to work and to perform routine errands and tasks. Even leisure time is increasingly filled with sedentary behaviors, such as watching television, “surfing” the Internet, and playing video games.

Increasing physical activity is a formidable public health challenge that we must hasten to meet. The stakes are high, and the potential rewards are momentous: preventing premature death, unnecessary illness, and disability; controlling health care costs; and maintaining a high quality of life into old age.

David Satcher, M.D., Ph.D.
Director
Centers for Disease Control
and Prevention

Philip R. Lee, M.D.
Assistant Secretary
for Health

Florence Griffith Joyner
Tom McMillen
Co-Chairs
President’s Council on
Physical Fitness and Sports

Preface
from the Surgeon General
U.S. Public Health Service

I am pleased to present the first report of the Surgeon General on physical activity and health. For more than a century, the Surgeon General of the Public Health Service has focused the nation's attention on important public health issues. Reports from Surgeons General on the adverse health consequences of smoking triggered nationwide efforts to prevent tobacco use. Reports on nutrition, violence, and HIV/AIDS—to name but a few—have heightened America's awareness of important public health issues and have spawned major public health initiatives. This new report, which is a comprehensive review of the available scientific evidence about the relationship between physical activity and health status, follows in this notable tradition.

Scientists and doctors have known for years that substantial benefits can be gained from regular physical activity. The expanding and strengthening evidence on the relationship between physical activity and health necessitates the focus this report brings to this important public health challenge. Although the science of physical activity is a complex and still-developing field, we have today strong evidence to indicate that regular physical activity will provide clear and substantial health gains. In this sense, the report is more than a summary of the science—it is a national call to action.

We must get serious about improving the health of the nation by affirming our commitment to healthy physical activity on all levels: personal, family, community, organizational, and national. Because physical activity is so directly related to preventing disease and premature death and to maintaining a high quality of life, we must accord it the same level of attention that we give other important public health practices that affect the entire nation. Physical activity thus joins the front ranks of essential health objectives, such as sound nutrition, the use of seat belts, and the prevention of adverse health effects of tobacco.

The time for this emphasis is both opportune and pressing. As this report makes clear, current levels of physical activity among Americans remain low, and we are losing ground in some areas. The good news in the report is that people can benefit from even moderate levels of physical activity. The public health implications of this good news are vast: the tremendous health gains that could be realized with even partial success at improving physical activity among the American people compel us to make a commitment and take action. With innovation, dedication, partnering, and a long-term plan, we should be able to improve the health and well-being of our people.

This report is not the final word. More work will need to be done so that we can determine the most effective ways to motivate all Americans to participate in a level of physical activity that can benefit their health and well-being. The challenge that lies ahead is formidable but worthwhile. I strongly encourage all Americans to join us in this effort.

Audrey F. Manley, M.D., M.P.H.
Surgeon General (Acting)

Acknowledgments

This report was prepared by the Department of Health and Human Services under the direction of the Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, in collaboration with the President's Council on Physical Fitness and Sports.

David Satcher, M.D., Ph.D., Director, Centers for Disease Control and Prevention, Atlanta, Georgia.

James S. Marks, M.D., M.P.H., Director, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Virginia S. Bales, M.P.H., Deputy Director, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Lisa A. Daily, Assistant Director for Planning, Evaluation, and Legislation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Marjorie A. Speers, Ph.D., Behavioral and Social Sciences Coordinator, Office of the Director, (formerly, Director, Division of Chronic Disease Control and Community Intervention, National Center for Chronic Disease Prevention and Health Promotion), Centers for Disease Control and Prevention, Atlanta, Georgia.

Frederick L. Trowbridge, M.D., Director, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Florence Griffith Joyner, Co-Chair, President's Council on Physical Fitness and Sports, Washington, D.C.

C. Thomas McMillen, Co-Chair, President's Council on Physical Fitness and Sports, Washington, D.C.

Sandra P. Perlmutter, Executive Director, President's Council on Physical Fitness and Sports, Washington, D.C.

Editors

Steven N. Blair, P.E.D., Senior Scientific Editor, Director of Research and Director, Epidemiology and Clinical Applications, The Cooper Institute for Aerobics Research, Dallas, Texas.

Adele L. Franks, M.D., Scientific Editor, Assistant Director for Science, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Dana M. Shelton, M.P.H., Managing Editor, Epidemiologist, Office on Smoking and Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

John R. Livengood, M.D., M.Phil., Coordinating Editor, Deputy Director, Epidemiology and Surveillance Division, National Immunization Program, (formerly, Associate Director for Science, Division of Chronic Disease Control and Community Intervention, National Center for Chronic Disease Prevention and Health Promotion), Centers for Disease Control and Prevention, Atlanta, Georgia.

Frederick L. Hull, Ph.D., Technical Editor, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Byron Breedlove, M.A., Technical Editor, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Editorial Board

Carl J. Caspersen, Ph.D., Epidemiologist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Aaron R. Folsom, M.D., M.P.H., Professor, Division of Epidemiology, School of Public Health, University of Minnesota, Minneapolis, Minnesota.

A Report of the Surgeon General

William L. Haskell, Ph.D., Professor of Medicine, Stanford University, Palo Alto, California.

Arthur S. Leon, M.D., M.S., Henry L. Taylor Professor and Director of the Laboratory of Physiological Hygiene and Exercise Science, Division of Kinesiology, University of Minnesota, Minneapolis, Minnesota.

James F. Sallis, Jr., Ph.D., Professor, Department of Psychology, San Diego State University, San Diego, California.

Martha L. Slattery, Ph.D., M.P.H., Professor, Department of Oncological Sciences, University of Utah Medical School, Salt Lake City, Utah.

Christine G. Spain, M.A., Director, Research, Planning, and Special Projects, President's Council on Physical Fitness and Sports, Washington, D.C.

Jack H. Wilmore, Ph.D., Professor, Department of Kinesiology and Health Education, University of Texas at Austin, Austin, Texas.

Richard W. Lymn, Ph.D., Muscle Biology Branch, National Institute of Arthritis and Musculoskeletal and Skin Diseases, National Institutes of Health, Bethesda, Maryland.

Russell R. Pate, Ph.D., Chairman, Department of Exercise Science, University of South Carolina, Columbia, South Carolina. Represented the American College of Sports Medicine.

Sandra P. Perlmutter, Executive Director, President's Council on Physical Fitness and Sports, Washington, D.C.

Bruce G. Simons-Morton, Ed.D., M.P.H., Behavioral Scientist, Prevention Research Branch, National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, Maryland.

Denise G. Simons-Morton, M.D., Ph.D., Leader, Prevention Scientific Research Group, DECA, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland.

Planning Board

Terry L. Bazzarre, Ph.D., Science Consultant, American Heart Association, Dallas, Texas.

Steven N. Blair, P.E.D., Senior Scientific Editor, Director of Research and Director, Epidemiology and Clinical Applications, The Cooper Institute for Aerobics Research, Dallas, Texas.

Willis R. Foster, M.D., Office of Disease Prevention and Technology Transfer, National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health, Bethesda, Maryland.

Patty Freedson, Ph.D., Department of Exercise Science, University of Massachusetts, Amherst, Massachusetts. Represented the American Alliance for Health, Physical Education, Recreation and Dance.

William R. Harlan, M.D., Associate Director for Disease Prevention, Office of the Director, National Institutes of Health, Bethesda, Maryland.

James A. Harrell, M.A., Deputy Commissioner, Administration on Children, Youth, and Families, (formerly, Deputy Director, Office of Disease Prevention and Health Promotion, Office of the Assistant Secretary for Health, Department of Health and Human Services), Washington, D.C.

Contributing Authors

Lynda A. Anderson, Ph.D., Public Health Educator, Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Carol C. Ballew, Ph.D., Epidemiologist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Jack W. Berryman, Ph.D., Professor, Department of Medical History and Ethics, School of Medicine, University of Washington, Seattle, Washington.

Lawrence R. Brawley, Ph.D., Professor, University of Waterloo, Ontario, Canada.

David R. Brown, Ph.D., Health Scientist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Physical Activity and Health

Lee S. Caplan, M.D., Ph.D., Medical Epidemiologist, Epidemiology and Statistics Branch, Division of Cancer Prevention and Control, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Ralph J. Coates, Ph.D., Chief, Epidemiology Section, Division of Cancer Prevention and Control, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Carlos J. Crespo, Dr.P.H., M.S., F.A.C.S.M., Public Health Analyst, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland.

Loretta DiPietro, Ph.D., M.P.H., Assistant Fellow and Assistant Professor of Epidemiology and Public Health, The John B. Pierce Laboratory and Yale University School of Medicine, New Haven, Connecticut.

Rod K. Dishman, Ph.D., Professor, Department of Exercise Science, University of Georgia, Athens, Georgia.

Michael M. Engelgau, M.D., Chief, Epidemiology and Statistics Branch, Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Walter H. Ettinger, M.D., Professor, Internal Medicine and Public Health Sciences, Bowman Gray School of Medicine, Winston-Salem, North Carolina.

David S. Freedman, Ph.D., Epidemiologist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Frederick Fridinger, Dr.P.H., C.H.E.S., Public Health Educator, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Gregory W. Heath, D.Sc., M.P.H., Epidemiologist/Exercise Physiologist, Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Wendy A. Holmes, M.S., Health Communications Specialist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Elizabeth H. Howze, Sc.D., Associate Director for Health Promotion, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Laura K. Kann, Ph.D., Chief, Surveillance Research Section, Division of Adolescent and School Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Abby C. King, Ph.D., Assistant Professor of Health Research and Policy and Medicine, Stanford University School of Medicine, Palo Alto, California.

Harold W. Kohl, III, Ph.D., Director of Research, Baylor College of Medicine, Baylor Sports Medicine Institute, Houston, Texas.

Jeffrey P. Koplan, M.D., M.P.H., President, Prudential Center for Health Care Research, Atlanta, Georgia.

Andrea M. Kriska, Ph.D., M.S., Assistant Professor, Department of Epidemiology, Graduate School of Public Health, University of Pittsburgh, Pittsburgh, Pennsylvania.

Barbara D. Latham, R.D., M.P.H., Public Health Nutritionist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

I-Min Lee, M.B.B.S., Sc.D., Assistant Professor of Medicine, Harvard Medical School, Boston, Massachusetts.

A Report of the Surgeon General

Elizabeth Lloyd, M.S., Statistician, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Bess H. Marcus, Ph.D., Associate Professor of Psychiatry and Human Behavior, Division of Behavior and Preventive Medicine, Miriam Hospital and Brown University School of Medicine, Providence, Rhode Island.

Dyann Matson-Koffman, Dr.P.H., M.P.H., C.H.E.S., Public Health Educator, Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Marion R. Nadel, Ph.D., Epidemiologist, Epidemiology and Statistics Branch, Division of Cancer Prevention and Control, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Eva Obarzanek, Ph.D., M.P.H., R.D., Nutritionist, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland.

Christine M. Plepys, M.S., Health Statistician, Division of Health Promotion Statistics, National Center for Health Statistics, Centers for Disease Control and Prevention, Hyattsville, Maryland.

Michael L. Pollock, Ph.D., Professor of Medicine, Physiology and Health and Human Performance; Director, Center for Exercise Science, University of Florida, Gainesville, Florida.

Michael Pratt, M.D., M.P.H., Medical Epidemiologist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Paul T. Rafor, M.D., M.P.H., Special Assistant to the Regional Health Administrator, Environmental Justice Programs, Office of Public Health Science, Region VIII, Department of Health and Human Services, U.S. Public Health Service, Denver, Colorado.

W. Jack Rejeski, Ph.D., Professor, Health and Sports Science, Wake Forest University, Winston-Salem, North Carolina.

Richard B. Rothenberg, M.D., M.P.H., F.A.C.P., Professor and Director, Preventive Medicine Residency Program, Department of Family and Preventive Medicine, Emory University School of Medicine, Atlanta, Georgia.

Mary K. Serdula, M.D., M.P.H., Acting Branch Chief, Chronic Disease Prevention Branch, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Charlotte A. Schoenborn, M.P.H., Health Statistician, National Center for Health Statistics, Centers for Disease Control and Prevention, Hyattsville, Maryland.

Denise G. Simons-Morton, M.D., Ph.D., Leader, Prevention Scientific Research Group, DECA, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland.

Elaine J. Stone, Ph.D., M.P.H., Health Scientist Administrator, Division of Epidemiology and Clinical Applications, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland.

Marlene K. Tappe, Ph.D., Visiting Behavioral Scientist, Division of Adolescent and School Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Wendell C. Taylor, Ph.D., M.P.H., Assistant Professor of Behavioral Sciences, School of Public Health, University of Texas Health Science Center at Houston, Houston, Texas.

Charles W. Warren, Ph.D., Statistician/Demographer, Division of Adolescent and School Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Deborah R. Young, Ph.D., Assistant Professor of Medicine, Division of Internal Medicine, The Johns Hopkins School of Medicine, Baltimore, Maryland.

Senior Reviewers

Elizabeth A. Arendt, M.D., Associate Professor of Orthopaedics, University of Minnesota, Minneapolis, Minnesota. Member, President's Council on Physical Fitness and Sports.

Elsworth R. Buskirk, Ph.D., Professor of Applied Physiology, Emeritus, Pennsylvania State University, University Park, Pennsylvania.

B. Don Franks, Ph.D., Professor and Chair, Department of Kinesiology, Louisiana State University, Baton Rouge, Louisiana. Senior Program Advisor, President's Council on Physical Fitness and Sports.

William R. Harlan, M.D., Associate Director for Disease Prevention, Office of the Director, National Institutes of Health, Bethesda, Maryland.

William P. Morgan, Ed.D., Professor, Department of Kinesiology, University of Wisconsin-Madison, Madison, Wisconsin.

Ralph S. Paffenbarger, Jr., M.D., Dr.P.H., Professor of Epidemiology (Retired-Active), Stanford University School of Medicine, Stanford, California.

Russell R. Pate, Ph.D., Chairman, Department of Exercise Science, University of South Carolina, Columbia, South Carolina. Represented the American College of Sports Medicine.

Roy J. Shephard, M.D., Ph.D., D.P.E., F.A.C.S.M., Professor Emeritus of Applied Physiology, University of Toronto, Toronto, Canada.

Peer Reviewers

Barbara E. Ainsworth, Ph.D., M.P.H., Associate Professor, Department of Epidemiology and Biostatistics, Department of Exercise Science, School of Public Health, University of South Carolina, Columbia, South Carolina.

Tom Baranowski, Ph.D., Professor, Department of Behavioral Science, University of Texas, M. D. Anderson Cancer Center, Houston, Texas.

Oded Bar-Or, M.D., Professor of Pediatrics and Director, Children's Exercise and Nutrition Centre, McMaster University, Chedoke Hospital Division, Hamilton, Ontario, Canada.

Charles B. Corbin, Ph.D., Professor, Department of Exercise Science and Physical Education, Arizona State University, Tempe, Arizona.

Kirk J. Cureton, Ph.D., Professor and Head, Department of Exercise Science, University of Georgia, Athens, Georgia.

Gail P. Dalsky, Ph.D., Assistant Professor of Medicine (in residence), University of Connecticut Health Center, Farmington, Connecticut.

Nicholas A. DiNubile, M.D., Clinical Assistant Professor, Department of Orthopaedic Surgery, Hospital of the University of Pennsylvania; Chief, Orthopaedic Surgery and Sports Medicine, Delaware County Memorial Hospital, Drexel Hill, Pennsylvania.

Barbara L. Drinkwater, Ph.D., Research Physiologist, Pacific Medical Center, Seattle, Washington.

Andrea L. Dunn, Ph.D., Associate Director, Division of Epidemiology and Clinical Applications, The Cooper Institute for Aerobics Research, Dallas, Texas.

Leonard H. Epstein, Ph.D., Professor, Department of Psychology, State University of New York at Buffalo, Buffalo, New York.

Katherine M. Flegal, Ph.D., Senior Research Epidemiologist, National Center for Health Statistics, Centers for Disease Control and Prevention, Hyattsville, Maryland.

Christopher D. Gardner, Ph.D., Research Fellow, Stanford Center for Research in Disease Prevention, Stanford University, Palo Alto, California.

Glen G. Gilbert, Ph.D., Professor and Chairperson, Department of Health Education, University of Maryland, College Park, Maryland.

Andrew P. Goldberg, M.D., Professor of Medicine and Director, Division of Gerontology, University of Maryland School of Medicine, Baltimore, Maryland.

John O. Holloszy, M.D., Professor of Internal Medicine, Washington University School of Medicine, St. Louis, Missouri.

Melbourne F. Hovell, Ph.D., M.P.H., Professor of Health Promotion; Director, Center for Behavioral Epidemiology, Graduate School of Public Health, College of Health and Human Services, San Diego State University, San Diego, California.

A Report of the Surgeon General

Caroline A. Macera, Ph.D., Director, Prevention Center, School of Public Health, University of South Carolina, Columbia, South Carolina.

JoAnn E. Manson, M.D., Dr.P.H., Co-Director of Women's Health, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts.

Jere H. Mitchell, M.D., Professor of Internal Medicine and Physiology; Director, Harry S. Moss Heart Center, University of Texas Southwestern Medical Center, Dallas, Texas.

James R. Morrow, Jr., Ph.D., Professor and Chair, Department of KHPR, University of North Texas, Denton, Texas.

Neville Owen, Ph.D., Professor of Human Movement Science, Deakin University, Melbourne, Australia.

Roberta J. Park, Ph.D., Professor of the Graduate School, University of California, Berkeley, California.

Peter B. Raven, Ph.D., Professor and Chair, Department of Integrative Physiology, University of North Texas Health Science Center, Fort Worth, Texas.

Judith G. Regensteiner, Ph.D., Associate Professor of Medicine, University of Colorado Health Sciences Center, Denver, Colorado.

Bruce G. Simons-Morton, Ed.D., M.P.H., Behavioral Scientist, Prevention Research Branch, National Institute of Child Health and Human Development, National Institutes of Health, Bethesda, Maryland.

Denise G. Simons-Morton, M.D., Ph.D., Leader, Prevention Scientific Research Group, DECA, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, Maryland.

James S. Skinner, Ph.D., Professor, Department of Kinesiology, Indiana University, Bloomington, Indiana.

Thomas Stephens, Ph.D., Principal, Thomas Stephens and Associates, Ottawa, Canada.

Anita Stewart, Ph.D., Associate Professor in Residence, University of California, San Francisco, San Francisco, California.

C. Barr Taylor, M.D., Professor of Psychiatry, Department of Psychiatry and Behavioral Sciences, Stanford University School of Medicine, Stanford, California.

Charles M. Tipton, Ph.D., F.A.C.S.M., Professor of Physiology and Surgery, University of Arizona, Tucson, Arizona.

Zung Vu Tran, Ph.D., Senior Research Scientist, Center for Research in Ambulatory Health Care Administration, Englewood, Colorado.

Other Contributors

Melissa M. Adams, Ph.D., Assistant Director for Science, Division of Reproductive Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Indu Ahluwalia, M.P.H., Ph.D., EIS Officer, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Betty A. Ballinger, Technical Information Specialist, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Sandra W. Bart, Policy Coordinator, Office of the Secretary, Executive Secretariat, Department of Health and Human Services, Washington, D.C.

Mary Bedford, Proofreader, Cygnus Corporation, Rockville, Maryland.

Caryn Bern, M.D., Medical Epidemiologist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Karil Bialostosky, M.S., Nutrition Fellow, National Center for Health Statistics, Centers for Disease Control and Prevention, Hyattsville, Maryland.

Physical Activity and Health

Thomas E. Blakeney, Program Analyst, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, Georgia.

Ronette R. Briefel, Dr.P.H., Nutrition Policy Advisor, National Center for Health Statistics, Centers for Disease Control and Prevention, Hyattsville, Maryland.

L. Diane Clark, M.P.H., Public Health Nutritionist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Janet L. Collins, Ph.D., Chief, Surveillance and Evaluation Research Branch, Division of Adolescent and School Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Janet B. Croft, Ph.D., Epidemiologist, Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Ann M. Cronin, Program Analyst, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Atlanta, Georgia.

Gail A. Cruse, M.L.I.S., Technical Information Specialist, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

John M. Davis, M.P.A., R.D., Public Health Analyst, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Earl S. Ford, M.D., M.P.H., Senior Scientist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Christine S. Fralish, M.L.I.S., Chief, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Emma L. Frazier, Ph.D., Mathematical Statistician, Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Deborah A. Galuska, M.P.H., Ph.D., EIS Fellow, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Dinamarie C. Garcia, M.P.H., C.H.E.S., Intern, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Linda S. Geiss, M.A., Health Statistician, Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Wayne H. Giles, M.D., M.S., Epidemiologist, Cardiovascular Health Section, Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Kay Sissions Golan, Public Affairs Specialist, Office of Communication (proposed), Centers for Disease Control and Prevention, Atlanta, Georgia.

Betty H. Haithcock, Editorial Assistant, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Helen P. Hankins, Writer-Editor, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

A Report of the Surgeon General

Rita Harding, Graphic Designer, Cygnus Corporation, Rockville, Maryland.

William A. Harris, M.M., Computer Specialist, Division of Adolescent and School Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Charles G. Helmick, III, M.D., Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Elizabeth L. Hess, Technical Editor, Cygnus Corporation, Rockville, Maryland.

Mary Ann Hill, M.P.P., Director of Communications, President's Council on Physical Fitness and Sports, Washington, D.C.

Thomya L. Hogan, Proofreader, Cygnus Corporation, Rockville, Maryland.

Judy F. Horne, Technical Information Specialist, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Catherine A. Hutsell, M.P.H., Public Health Educator, Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Robert Irwin, Special Assistant, Office of the Director, Centers for Disease Control and Prevention, Washington, D.C.

Sandra E. Jewell, M.S., Statistician, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Loretta G. Johnson, Secretary, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Deborah A. Jones, Ph.D., Epidemiologist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Wanda K. Jones, M.P.H., Dr.P.H., Associate Director for Women's Health, Office of Women's Health, Centers for Disease Control and Prevention, Atlanta, Georgia.

Robert E. Keaton, Consultant, Cygnus Corporation, Rockville, Maryland.

Delle B. Kelley, Technical Information Specialist, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Mescal J. Knighton, Writer-Editor, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Sarah B. Knowlton, J.D., M.S.W., Attorney Advisor, Office of the General Council, Centers for Disease Control and Prevention, Atlanta, Georgia.

Fred Kroger, Acting Director, Health Communication, Office of Communication (proposed), Centers for Disease Control and Prevention, Atlanta, Georgia.

Sarah A. Kuester, M.P.H., R.D., Public Health Nutritionist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Becky H. Lankenau, M.S., R.D., M.P.H., Dr.P.H., Public Health Nutritionist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Nancy C. Lee, M.D., Associate Director for Science, Division of Cancer Prevention and Control, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Physical Activity and Health

Leandris C. Liburd, M.P.H., Public Health Educator, Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Richard Lowry, M.D., M.S., Medical Epidemiologist, Division of Adolescent and School Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Salvatore J. Lucido, M.P.A., Program Analyst, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Gene W. Matthews, Esq., Legal Advisor to CDC and ATSDR, Office of the General Council, Centers for Disease Control and Prevention, Atlanta, Georgia.

Brenda W. Mazzocchi, M.S.L.S., Technical Information Specialist, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Sharon McDonnell, M.D., M.P.H., Medical Epidemiologist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Michael A. McGeehin, Ph.D., M.S.P.H., Chief, Health Studies Branch, Division of Environmental Hazards and Health Effects, National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia.

Zuguo Mei, M.D., M.P.H. Visiting Scientist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

James M. Mendlein, Ph.D., Epidemiologist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Robert K. Merritt, M.A., Behavioral Scientist, Office on Smoking and Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Gaylon D. Morris, M.P.P., Program Analyst, Office of Program Planning and Evaluation, Centers for Disease Control and Prevention, Atlanta, Georgia.

Melba Morrow, M.A., Division Manager, The Cooper Institute for Aerobics Research, Dallas, Texas.

Marion R. Nadel, Ph.D., Epidemiologist, Division of Cancer Prevention and Control, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

David E. Nelson, M.D., M.P.H., Medical Officer, Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Reba A. Norman, M.L.M., Technical Information Specialist, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Ward C. Nyholm, Graphic Designer, Cygnus Corporation, Rockville, Maryland.

Stephen M. Ostroff, M.D., Associate Director for Epidemiologic Science, National Center for Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia.

Ibrahim Parvanta, M.S., Acting Deputy Chief, Maternal and Child Health Branch, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Terry F. Pechacek, Ph.D., Visiting Scientist, Office on Smoking and Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

A Report of the Surgeon General

Geraldine S. Perry, Dr.P.H., Epidemiologist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Todd M. Phillips, M.S., Deputy Project Director, Cygnus Corporation, Rockville, Maryland.

Audrey L. Pinto, Writer-Editor, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Kenneth E. Powell, M.D., M.P.H., Associate Director for Science, Division of Violence Prevention, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, Georgia.

Julia H. Pruden, M.Ed., R.D., Public Health Nutritionist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

David C. Ramsey, M.P.H., Public Health Educator, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Brenda D. Reed, Secretary, Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Susan A. Richardson, Writer-Editor, Cygnus Corporation, Rockville, Maryland.

Christopher Rigaux, Project Director, Cygnus Corporation, Rockville, Maryland.

Angel Roca, Program Analyst, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Cheryl V. Rose, Computer Specialist, Division of Health Promotion Statistics, National Center for Health Statistics, Centers for Disease Control and Prevention, Hyattsville, Maryland.

Patti Schwartz, Graphic Designer, Cygnus Corporation, Rockville, Maryland.

Bettylou Sherry, Ph.D., Epidemiologist, Maternal and Child Health Branch, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Margaret Leavy Small, Behavioral Scientist, Division of Adolescent and School Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Joseph B. Smith, Senior Project Officer, Disabilities Prevention Program, National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia.

Terrie D. Sterling, Ph.D., Research Psychologist, Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Emma G. Stupp, M.L.S., Technical Information Specialist, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

William I. Thomas, M.L.I.S., Technical Information Specialist, Technical Information and Editorial Services Branch, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Patricia E. Thompson-Reid, M.A.T., M.P.H., Program Development Consultant/Community Interventionist, Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Jenelda Thornton, Staff Specialist, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Physical Activity and Health

Nancy B. Watkins, M.P.H., Health Education Specialist, Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Howell Wechsler, Ed.D., M.P.H., Health Education Research Scientist, Division of Adolescent and School Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Julie C. Will, Ph.D., M.P.H., Epidemiologist, Division of Nutrition and Physical Activity, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Lynda S. Williams, Program Analyst, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

David F. Williamson, Ph.D., Acting Director, Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Stephen W. Wyatt, D.M.D., M.P.H., Director, Division of Cancer Prevention and Control, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

Matthew M. Zack, M.D., M.P.H., Medical Epidemiologist, Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, Atlanta, Georgia.

PHYSICAL ACTIVITY AND HEALTH

Chapter 1: Introduction, Summary, and Chapter Conclusions	1
Chapter 2: Historical Background, Terminology, Evolution of Recommendations and Measurement	9
Western Historical Perspective	12
Terminology of Physical Activity, Physical Fitness, and Health	20
Evolution of Physical Activity Recommendations	22
Summary of Recent Physical Activity Recommendations	28
Measurement of Physical Activity, Fitness, and Intensity	29
Chapter 3: Physiologic Responses and Long-Term Adaptations to Exercise	61
Physiologic Responses to Episodes of Exercise	61
Long-Term Adaptations to Exercise Training	67
Maintenance, Detraining, and Prolonged Inactivity	71
Special Considerations	73
Chapter 4: The Effects of Physical Activity on Health and Disease	81
Overall Mortality	85
Cardiovascular Diseases	87
Cancer	112
Non-Insulin-Dependent Diabetes Mellitus	125
Osteoarthritis	129
Osteoporosis	130
Obesity	133
Mental Health	135
Health-Related Quality of Life	141
Adverse Effects of Physical Activity	142
Occurrence of Adverse Effects	144
Nature of the Activity/Health Relationship	144
Chapter 5: Patterns and Trends in Physical Activity	173
Physical Activity among Adults in the United States	177
Physical Activity among Adolescents and Young Adults in the United States	186
Chapter 6: Understanding and Promoting Physical Activity	209
Theories and Models Used in Behavioral and Social Research on Physical Activity	211
Behavioral Research on Physical Activity among Adults	215
Behavioral Research on Physical Activity among Children and Adolescents	234
Promising Approaches, Barriers, and Resources	243
List of Tables and Figures	261
Index	265